MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, SESSION 2022/2023 (TERM ID 2210)

EEL3036 – POWER SYSTEM ANALYSIS

(LE)

7 FEBRUARY 2023
9 a.m – 11 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question Paper consists of 5 pages including the cover page with FOUR Questions only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) The American National Standards Institute and the Institute of Electrical and Electronics Engineers have published a set of standard symbols for electrical diagrams to be used in per-phase equivalent circuit. Sketch the symbol for the following commonly used apparatus in the one-line diagram: three-phase wye with neutral grounded, three-winding power transformer, fuse, oil circuit breaker, current transformer, potential transformer, air circuit breaker, two-winding power transformer and machines. [9 marks]

(b) **Figure Q1(b)** shows the one-line diagram of a power system with all impedances showing in per unit on a 100-MVA base. The three-phase power and line-to-line ratings are given below:

G_1:	100 MVA	20 kV	$X = 0.09$ p.u.
T_1:	60 MVA	22 kV/200 kV	$X = 0.16$ p.u.
T_2:	60 MVA	200kV/22 kV	$X = 0.02$ p.u.
G_2 :	100 MVA	18 kV	$X = 0.09$ p.u.
Line:		200 kV	$X = 120$ ohms
Load:		200 kV	$S = 48$ MW + $j64$ Mvar

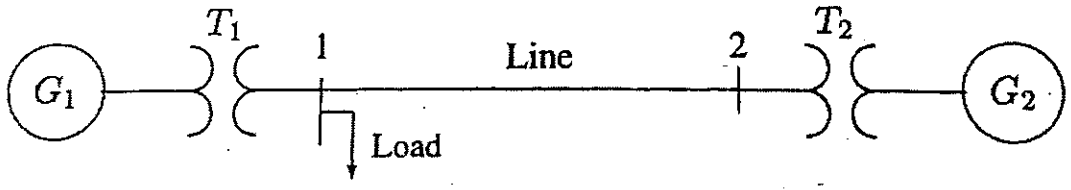

Figure Q1(b)

Draw an impedance diagram for the system by showing all impedances in per unit on 100-MVA base. Choose 200 kV at the transmission line as the common voltage base. [16 marks]

Question 2

In the power system network shown in **Figure Q2**, bus 1 is a slack bus with bus voltage of $1.05\angle 0^0$ per unit. The line impedance on a base of 100 MVA is as marked in the diagram.

(a) Using Gauss Seidel method, determine the phasor value of V_2 at the end of the first iteration. State the assumption(s) used in this power flow solution method. [8 marks]

(b) Write the elements in the Jacobian matrix used in the Newton-Raphson method. Then, calculate the ***second*** row elements of the Jacobian matrix. State the assumption(s) used in this power flow solution method. [11 marks]

(c) Use the Fast-decoupled Newton-Raphson to calculate the angle corrections in radians. [6 marks]

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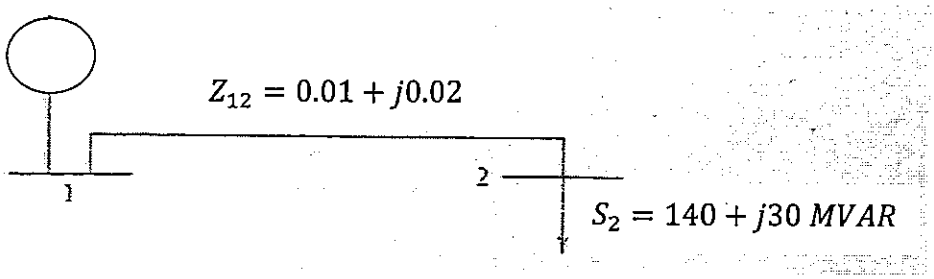

Figure Q2

Question 3

(a) A 50 MVA, 11 kV, Y-connected synchronous generators with the neutral point solidly grounded, has a zero-sequence reactance of 0.2 p.u., a positive-sequence reactance of 0.3 p.u. and a negative-sequence reactance of 0.4 p.u.. Assuming a line-to-line-to-ground fault (*b*-*c*-ground) has occurred to the system while the generator is initially unloaded and operating at rated voltage.

(i) Sketch and label the sequence network. [2 marks]

(ii) Determine the resulting sequence currents (I_{a0}, I_{a1}, I_{a2}). [6 marks]

(b) A generator having a solidly grounded neutral point and rated at 50 MVA, 30 kV has positive-, negative-, and zero-sequence reactances of 25, 15 and 5 percent, respectively. Determine the reactance value that must be placed in the generator neutral to limit the fault current for a bolted line-to-ground fault to that for a bolted three-phase fault. [4 marks]

(c) The system shown in **Figure Q3(c)** is initially on no load with generators operating at their rated voltage with their emfs in phase. The rating of the generators and the transformers and their respective percent reactances are marked on the diagram All resistances are neglected. The line impedance is $j160$ ohms. A three-phase balanced fault occurs at the receiving end of the transmission line.

(i) Draw and label the impedance diagram. [8 marks]

(ii) Find the short-circuit current in Ampere. [3 marks]

(iii) Calculate and design for the short-circuit capacity for the circuit breaker at the faulted bus. [2 marks]

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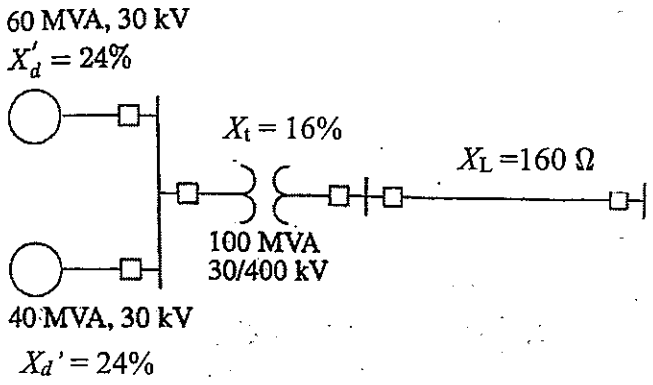

Figure Q3(c)

Question 4

(a) **Figure Q4(a)** shows a 60 Hz synchronous generator with inertia constant, H of 6 MJ/MVA and a direct axis transient reactance, X_d'= 0.2 per unit. The generator is connected to an infinite bus through a purely reactive line, where the reactances of the transmission lines are marked on a common system base. The generator is delivering real power P_e = 0.77 per unit and reactive power Q = 0.072 per unit to the infinite bus at a voltage of 1.0 per unit. A temporary three-phase fault occurs at the sending end of the line at point F. When the fault is cleared, both lines are intact.

(i) Calculate the current flowing into the infinite bus. [1 marks]

(ii) Determine the transient internal voltage. [2 marks]

(iii) Determine the initial operating angle, δ_0 in radian. [2 marks]

(iv) Find the critical clearing angle, δ_c in radian. [2 marks]

(v) Calculate the critical clearing time, t_c. [3 marks]

(vi) Sketch and label the power-angle curve of the case. [1 marks]

[Hint: $t_c = \sqrt{\dfrac{2H(\delta_c - \delta_0)}{\pi f P_m}}$]

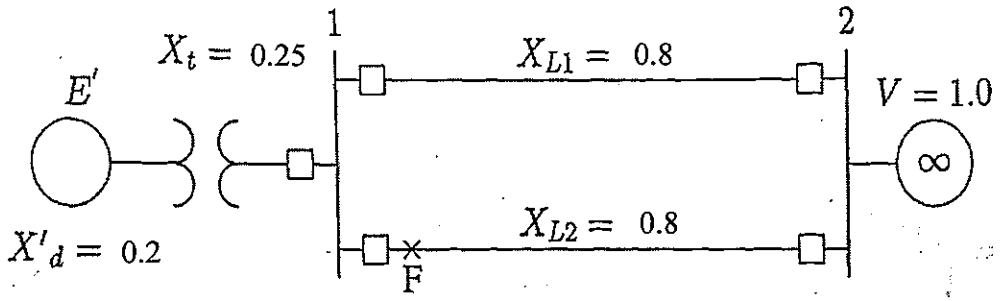

Figure Q4(a)

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(b) A multi-machine power system is as shown in **Figure Q4(b).** The reactance of each transmission line is $j0.2$ p.u. and the corresponding Y_{BUS} matrix is as given below:

$$Y_{BUS} = \begin{bmatrix} -j10 & j5 & j5 \\ j5 & -j10 & j5 \\ j5 & j5 & -j10 \end{bmatrix}$$

(i) Sketch and label the augmented system corresponding to the system shown in **Figure Q4(b)**. [4 marks]

(ii) Calculate the admittance of the loads. [3 marks]

(iii) Determine the pre-fault augmented bus admittance matrix. [7 marks]

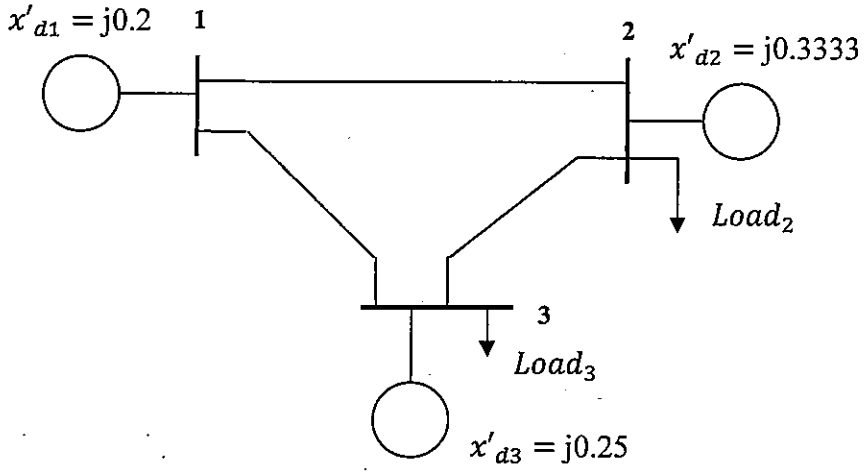

Figure Q4(b)

Table Q4(b)

Bus. No.	Voltage magnitude	Voltage angle in deg.	Generation		Load	
			P_G (p.u.)	Q_G (p.u.)	P_L (p.u.)	Q_L (p.u.)
1	1.050	0	1.50	0.30	0	0
2	1.020	-4.6	1.25	0.35	2.50	1.00
3	1.025	-3.3	1.50	1.00	1.50	1.00

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